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ABSTRACT

Intended primarily but not solely for use at the postsecondary level, this curriculum guide contains five units on energy efficiency that were designed to be incorporated into an existing program in electrical technology. The following topics are examined: where to look for energy waste; conservation methods for electrical consumers, for electrical designers, and for electrical contractors; and additional conservation practices. Covered in each unit are unit rationale, necessary advanced preparation, anticipated instructional time, guidelines for implementing the unit, unit activities, and unit references. (MN)

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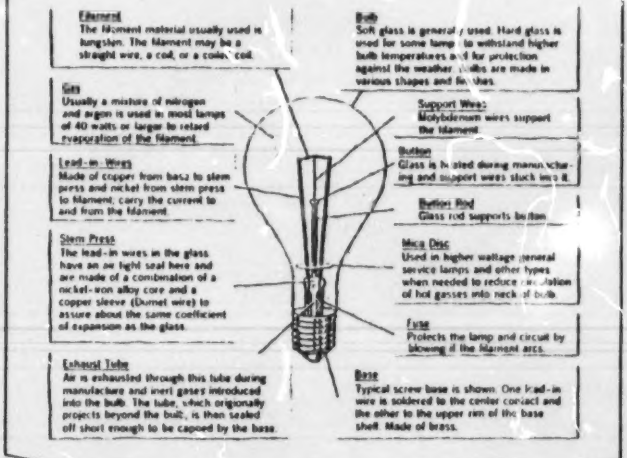
ENERGY EFFICIENCY FOR ELECTRICAL TECHNOLOGY


Filament
The filament material usually used is tungsten. The filament may be a straight wire, a coil, or a coil-in-coil.
Gas
Usually a mixture of nitrogen and argon is used in most lamps of 40 watts or larger to retard evaporation of the filament.
Lead-in Wires
Made of copper from base to stem press and nickel from stem press to filament, carry the current to and from the filament.
Stem Press
The lead-in wires in the glass have an air tight seal here and are made of a combination of a nickel-iron alloy core and a copper sleeve (Dumet wire) to assure about the same coefficient of expansion as the glass.
Exhaust Tube
Air is exhausted through this tube during manufacture and inert gases introduced into the bulb. The tube, which originally projects beyond the bulb, is then sealed off short enough to be capped by the base.
Bulb
Soft glass is generally used. Hard glass is used for some lamps to withstand higher bulb temperatures and for protection against the weather. Bulbs are made in various shapes and finishes.
Support Wires
Molybdenum wires support the filament.
Button
Glass is heated during manufacturing and support wires stuck into it.
Button Rod
Glass rod supports button.
Mica Disc
Used in higher wattage general service lamps and other types when needed to reduce convection of hot gasses into neck of bulb.
Fuse
Protects the lamp and circuit by blowing if the filament arcs.
Base
Typical screw base is shown. One lead-in wire is soldered to the center contact and the other to the upper rim of the base shell. Made of brass.

Edited by:

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CE 033 355

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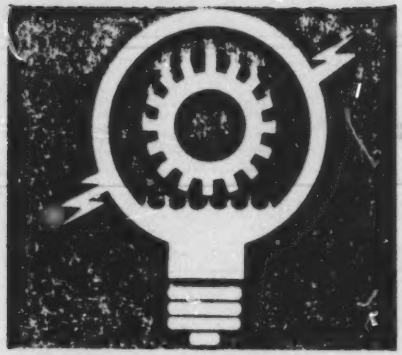

PREFACE

This curriculum guide was produced by the Nebraska Energy Office in a cooperative effort with the Nebraska State Department of Education. These organizations are dedicated to the development of quality educational materials that promote wise energy management.

The following individuals assisted in the production of these materials:

Ronald Jantzi, Supervisor - Trade and Industrial Education, Nebraska Department of Education, Lincoln, Nebraska;
Ivan Nickerson, Electrical Trades Instructor, Mid-Plains Community College, North Platte, Nebraska;
Larry Scharmann, Education Coordinator, Nebraska Energy Office, Lincoln, Nebraska; and
Bob Schulz, Electrical Trades Instructor, Northeast Technical Community College, Norfolk, Nebraska.

This project was supported by the Nebraska Energy Office with federal funds disbursed under P.L. 94-163 and P.L. 94-385.

These materials will be piloted during the 1981-1982 school year, revised, and subsequently made available statewide for the 1982-1983 academic year.

All inquiries, suggestions or comments regarding this curriculum guide should be directed to:

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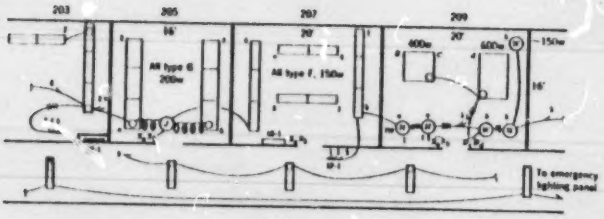


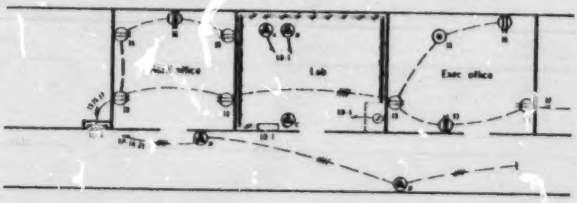
INTRODUCTION

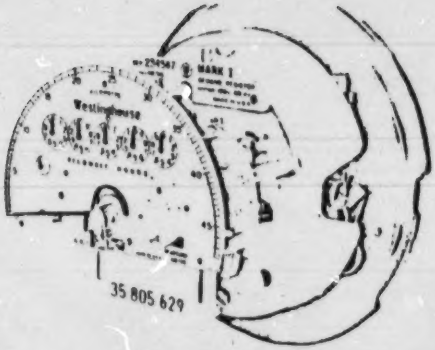
This curriculum guide contains five units that were designed to be incorporated into an existing program in electrical technology. The material is primarily intended for use at the postsecondary level. A well-equipped secondary instructor, however, will also find the information useful.

The five units may be taught independently or collectively depending on the needs of the instructor at any single institution. The content of these units has been written and organized into an outline format. Each unit outline, in order to facilitate articulation between units, consists of the following sections: rationale, advanced preparation, anticipated instructional time, unit guide, activities, and references.

The degree of coverage depth, instructional time, and evaluation of student performance are left at the discretion of the individual instructor. Suggested activities are included but are by no means comprehensive. Instructors should feel free to add, delete, or substitute activities, references, and audiovisual materials. The Nebraska Energy Office encourages innovation to best suit the needs of the individual instructor.

The overall objective of this curriculum guide is to provide the electrical instructors in Nebraska with a format to achieve continuity in their approach to teaching energy efficiency for electrical installations.





COURSE RATIONALE

This course is designed to promote the understanding and application of some important electrical energy conservation practices. It is our intent to provide the student with sufficient information to expand his/her working knowledge beyond maintenance and operation. A thorough understanding of the principles discussed in the units to follow, will allow the student to maximize the potential energy efficiency of electrical systems.

The principle electrical energy conservation practices are discussed in the following units:

1. Where to Look for Energy Waste - Excessive or unnecessary use of any energy source is certainly a form of energy waste. This unit covers some of these areas.

2. Conservation Methods for Electrical Consumers - Covers methods that the consumer may employ to correct wasteful practices.

3. Conservation Methods for Electrical Designers - Methods for the conservation of electrical energy through improved electrical systems design.

4. Conservation Methods for Electrical Contractors - Construction methods electrical contractors may use to improve electrical efficiency.

5. A Look Beyond - Explores additional electrical conservation practices.

UNIT I

WHERE TO LOOK FOR ENERGY WASTE

RATIONALE

While much has been written in the past few years regarding the conservation of energy, too often we expect new innovations or technological advances to solve our problems for us. The single, most important aspect of energy conservation is the ability to recognize the methods and practices that contribute to energy waste and reduce or eliminate such practices. It is the responsibility of the electrical tradesman to consider planning or retrofitting a building for energy efficiency.

This unit identifies many, but by no means all, places where energy waste may occur.

ADVANCED PREPARATION

It is recommended that the publications "Tips for Energy Savers" and "Nebraska Energy Saving Manual" be obtained from the Nebraska Energy Office prior to beginning this unit.

ANTICIPATED INSTRUCTIONAL TIME

1-3 weeks

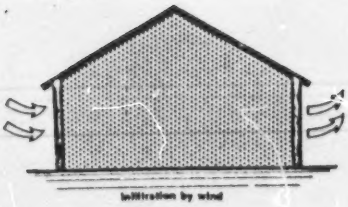
UNIT GUIDE

1. INFILTRATION

   Any building will constantly exchange air with its environment: outside air leaks in, inside air leaks out. A certain amount of this exchange (say, one complete air change per hour) is necessary for ventilation, but most buildings have much more than is needed. In winter, the air that leaks in is cold; the air that leaks out is warm; fuel is used to supply this temperature difference. Exfiltration (the flow of air is always from hot to cold) is the main reason for a cold house.

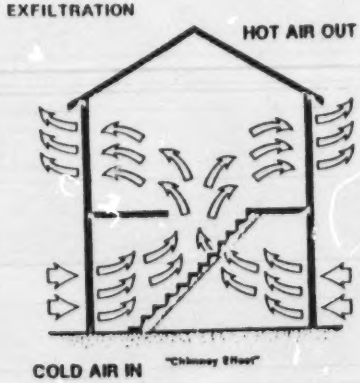
   This leakage or infiltration is caused by wind, the building acting as a chimney, and the opening of outside doors.

FIGURE ONE



The effect of door openings and wind needs little explanation, but the chimney effect may not be obvious. When air in a building is warmer than the outside air, the entire building acts like a chimney- hot air tends to rise and leak out of cracks at the lower levels. Both the temperature difference and building height contribute to this effect. A two-story house having a 68°F inside temperature and a 30°F outside temperature will produce a "chimney" leakage equivalent to a 10 mile per hour wind blowing against the building.

FIGURE TWO



Each cubic foot of air that enters the house requires approximately 0.02 Btu to raise the temperature 1°F. To determine the heat loss from infiltration, it is necessary to know the rate of air movement through the home. Most houses undergo from one to three air changes per hour, depending on construction. (See FIGURE THREE).

Specific areas of infiltration include:

A. Windows
B. Doors
C. Gas Vents
D. Chimneys
E. Dryer Vents
F. Exhaust Fans
G. Light Fixtures
H. Wall Switches and Receptacles
I. Thermostat
J. Utility Wall Openings
K. Attic Access Doors

FIGURE THREE

	INFILTRATION RATES		
Building Component	One Air Change Per Hour	Two Air Changes Per Hour	Three Air Changes Per Hour
Building with cellar OR	Tight, no cracks, caulked sills, sealed cellar windows, no grade entrance leaks	Some foundation cracks, no weatherstripping on cellar windows, grade entrance not tight	Stone foundation, considerable leakage area, poor seal around grade entrance
Building with crawl space or on posts	Plywood floor, no trap door leaks, no leaks around water, sewer and electrical openings	Tongue and groove board floor, reasonable fit on trap door, around pipes etc.	Board floor, loose fit around pipes, etc.
Windows	Storm windows with good fit	No storm windows, good fit on regular windows	No storm windows, loose fit on regular windows
Doors	Good fit on storm doors	Loose storm doors, poor fit on side door	No storm doors, loose fit on inside door
Walls	Caulked windows and doors, building paper used under siding	Caulking in poor repair	No indication of building paper, evident cracks around door and window frame.

2. INSULATION

A. Maintain minimum recommended insulation (check with local building official to ensure compliance with all appropriate codes).

B. Insulate basement walls

C. Insulate under floors (above crawl spaces)

D. Ventilate attics and crawl spaces to retain insulation values

E. In new construction, make sure that insulation is properly installed around windows, doors, in corners, etc.

3 LIGHTING

A. Excessive wattage

B. Not shut off after use

C. Improper switching (arrangement) design

D. Avoid indirect and recessed lighting

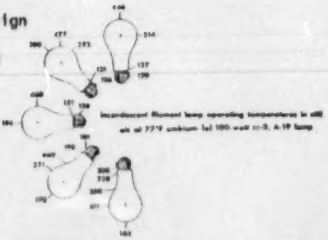
E. Poor lighting fixture efficiency

F. Poor interior decorating

G. Poor lighting layout

H. Dirty fixtures and windows

I. Irregular lamp replacement program



J. Improper repair and maintenance of luminaires

K. Excessive use of decorative and advertising lighting

4. INADEQUATE ELECTRICAL SYSTEM

A. Inadequate service entrance size

B. Inadequate size for feeder and branch circuit wires

C. Insufficient electrical outlet capacity

D. Poor electrical workmanship
   1. Safety hazard
   2. Poor connections can cause increased electrical energy consumption.

E. Use of old, outdated, or worn electrical equipment

F. Low or high voltage conditions

G. Defective electrical utility equipment

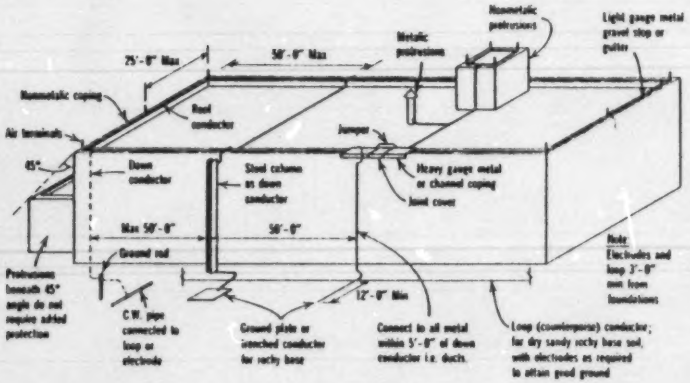
H. Poor power factor

I. Improper maintenance procedures

J. Improper transformer size

K. Use of low efficiency motors or appliances

FIGURE FOUR


Nonmetalic protrusions
Light gauge metal gravel stop or gutter
Metalic protrusions
25'-0" Max
50'-0" Max
Nonmetalic coping
Roof conductor
Air terminals
Jumper
45°
Down conductor
Steel column as down conductor
Heavy gauge metal or channel coping
Joint cover
Max 50'-0"
50'-0"
Ground rod
Note: Electrodes and loop 3'-0" out from foundations
Protrusions beneath 45° angle do not require added protection
C.W. pipe connected to loop or electrode
Ground plate or trenched conductor for rocky base
12'-0" Min
Connect to all metal within 5'-0" of down conductor i.e. ducts.
Loop (counterpoise) conductor; for dry sandy rocky base soil, with electrodes as required to obtain good ground

Typical lightning protection diagram

5. MECHANICAL LOSSES

A. Dirty heating and ventilating filters

B. Worn or improperly adjusted belts or drives

C. Improperly sized motors

D. Improperly aligned equipment

E. Scale deposits in water heaters or boilers

F. Overloaded equipment

G. Insufficient lubrication

H. Improper equipment location or installation

6. INEFFICIENT ENERGY USAGE

A. Use of appliances at less than optimum capacity
   1. Dishwashers
   2. Refrigerators
   3. Air conditioners, etc.

B. Unnecessary, long warmup of heating equipment

C. Excessive lighting
   1. Unoccupied rooms
   2. Improper wattage

D. Irrigating in excess of crop demand

E. Operating motorized or electrical equipment when unnecessary

F. Improper thermostat settings

G. Failure to cooperate with utility supplier to eliminate "high peak" demand loads

H. Failure to adjust production schedules to eliminate "high peak" demands

I. Excessive outside makeup air (heating)

J. Failure to combine room use for several purposes

K. Failure to use insulating cover for heated swimming pools

UNIT ACTIVITIES

1. Have students go through a building and identify areas where infiltration is a problem. Have them suggest methods for reducing infiltration.

2. Have students identify areas where insulation is required. This should include a discussion of insulation types, amounts, cost/effectiveness, and R-values.

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3. The student should be able to make an energy waste survey of an office building and determine where good conservation practices are not being following in regards to lighting and switching arrangements.

4. The student should be able to identify problem arees in an electrical system that may be inefficient and check appliances for any malfunction that could be wasting energy.

5. The student should examine areas in the mechanical building, roof top units, thru-wall units, and make a checklist of problems that have developed (or probable problem areas).

UNIT REFERENCES

The following publications are available from the:

Nebraska Energy Office
P.O. Box 95085
Lincoln, NE 68509

1. Nebraska Energy Saving Manual (50¢ per book)
2. Tips for Energy Savers

UNIT II

ENERGY CONSERVATION METHODS FOR ELECTRICAL CONSUMERS

RATIONALE

The conservation of energy requires a concerted effort by all sectors of the American energy-consuming public. In the transportation sector, for instance, we are informed that proper driving techniques, trip planning, and simple maintenance will save gasoline. In the same manner, proper operation of the electrical equipment in our homes, businesses, and industries can result in large energy savings.

The persons directly involved in the installation and sale of electrical equipment and energy (i.e. - electrical contractors, engineers, and electrical utility employees) are responsible for guiding and counseling consumers in the most efficient use of electrical energy.

This Unit explores some of the areas where electrical energy conservation methods may be implemented.

ADVANCED PREPARATION

It is recommended that the publication "Nebraska Energy Saving Manual" be obtained from the Nebraska Energy Office prior to beginning this unit.

ANTICIPATED INSTRUCTIONAL TIME

1-3 weeks

UNIT GUIDE

1. LIGHTING

   A. Turn off lights in any unoccupied room

   B. Light-zone homes to save electricity

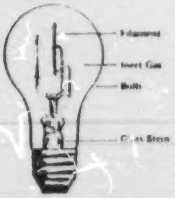
   C. Remove high wattage bulbs and replace them with smaller wattage bulbs in non-working areas.

   D. Use one large bulb instead of several small ones in areas where bright light is required.

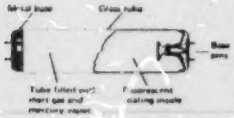
   E. Efficiencies of incandescent bulbs increase as the wattage increases.

FIGURE FIVE

Incandescent Bulb



Fluorescent Tube Cross Section



F. Long-life bulbs
   1. least efficient of any incandescent bulbs
   2. Light output sacrificed in favor of long life
   3. Use only where bulbs are difficult to replace

G. Keep all lamps and lighting fixtures clean

H. Consider fluorescent lighting for:
   1. Kitchen sink and countertop
   2. Bath area

I. Use outdoor lights only when they are necessary
   1. Timers
   2. Photocells

J. Make use of natural lighting whenever possible

K. Use dimming switches to reduce lighting levels

L. Utilize multiple switching for selective lighting levels in offices, conference rooms, family rooms, etc.

M. Reduce parking lot lighting to minimum levels required for safety.

N. Use specially designed fluorescent lamps that produce approximately the same amount of lumens as incandescent bulbs (require less energy consumption).

O. Maintain a regular lamp replacement schedule.

2. APPLIANCES

A. Hot Water Heaters and Boilers
   1. Drain water heaters and boilers at scheduled intervals to help eliminate sediment "buildup" on heating elements.
   2. Add insulation around the water heater and hot water pipes
   3. Check temperature of water heater thermostat setting
   4. Check heating elements

B. Laundry Equipment
   1. Use laundry equipment at or near rated capacity
   2. Use cold water whenever possible
   3. Keep the lint screen in the dryer clean
   4. Keep the outside exhaust of the clothes dryer clean
   5. Dry clothes in consecutive loads
   6. Use clothes lines whenever possible

NOTE: There are devices on the market that can be installed in the dryer exhaust duct that will trap lint and direct the heat and humidity back into the laundry area.

C. Garbage Disposal
   1. Use cold water to flush the unit instead of hot water
   2. Keep cutting blades sharp

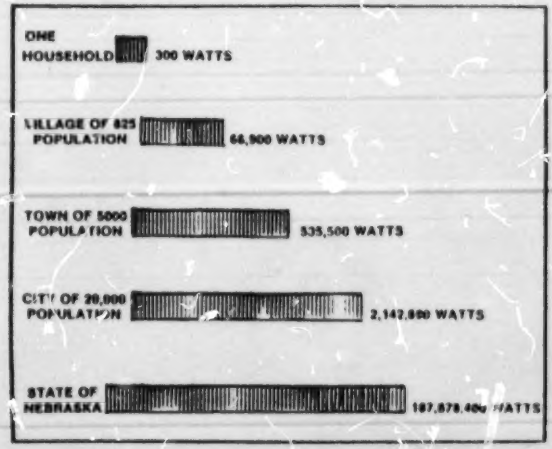
D. Dishwashers
   1. Run dishwashers only at full capacity
   2. When purchasing a dishwasher, look for a model with air-power and/or overnight dry settings
   3. Keep heating element free of sludge buildup
   4. Let dishes air-dry
   5. Don't use the "rinse hold" selection

E. Other household appliances
   1. If refrigeration equipment has a power saver switch, consult manufacturer's guide for proper operation
   2. Don't keep a refrigerator or freezer too cold
   3. Make sure all doors seals are tight
   4. Consider buying refrigerators and freezers that have to be manually defrosted
   5. Regularly defrost manual-defrost refrigerators and freezers. Frost buildup increases the amount of energy needed to keep the compressor running. Never allow frost to build up more than one quarter of an inch
   6. On ranges, match the size of the pan to the heating element
   7. Keep range-top burners and reflectors clean
   8. Never boil water in an open pan
   9. Cooking with electricity, get in the habit of turning off the burners several minutes before the allotted cooking time
   10. When using the oven, make the most of the heat from that single source
   11. Watch the clock or use a timer

12. Don't leave your appliances running when they are not in use.
13. Keep appliances in good working order
14. When buying appliances, read labels carefully, and purchase the appliance with the lowest estimated annual operating costs.

FIGURE SIX

This graph shows the approximate power wasted if every household operates a 300 watt color television receiver for one hour each day with no one watching



The electrical energy wasted in only one day of excess television operation in the state of Nebraska would supply all of the electrical energy required for all of the 223 households in the village of 625 population for a whole month using an average of 750,000 watts per month per household.

3. HEATING AND COOLING SYSTEMS

A. Close off unoccupied rooms

B. Use kitchen, bath and other ventilating fans sparingly

C. Keep a fireplace damper closed unless a fire is going

D. Consider the advantage of a clock thermostat for heating systems

E. Clean or replace the filter in a forced-air heating system each month

F. Check the duct work for air leaks about once a year in forced-air heating systems

G. During air-conditioning season, keep out daytime sun

H. Have air-conditioners checked each cooling season

I. On forced-air systems check motor bearing, drive belts, etc. each heating season

J. Check for possible infiltration around thermostat mounting plate.

K. Keep sunlight or any heat-producing items such as table lamps, TV, etc. away from the thermostat

L. Check the thermostat heat anticipator for proper setting

M. Remove heat from attics by installing a roof power vent

N. Check and clean attic vents and check for proper sizing

O. Use storm windows year round

HEATED AIR CIRCULATION (Also Showing Combustion Air Circulation)

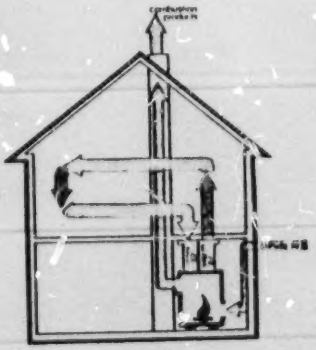


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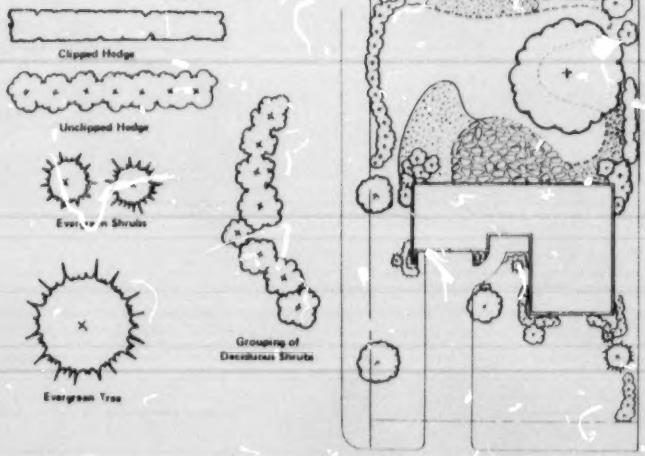
FIGURE SEVEN



4. DECORATING AND LANDSCAPING

A. Plant deciduous trees and vines on south and west sides of the home.

B. Consider solar heat gain when you plan window location
   1. In cool climates, install fewer windows on the north wall because there's little solar heat gain
   2. Maintain some window area on the north for ventilation purposes

C. Install windows you can open

D. Place refrigerators in the coolest part of the kitchen

E. Install the water heater as close as possible to areas of major use

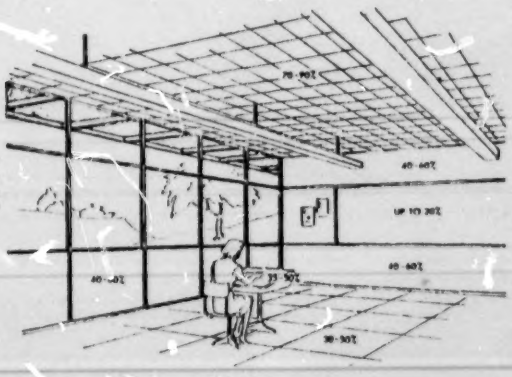
F. For warmer climates, light colored roofing can help keep homes cooler

G. Fluorescent lights:
   1. Provide more lumens per watt
   2. Produce less heat
   3. Effective for makeup and grooming areas

H. Use light colors for walls, rugs, draperies, and upholstery to reflect light and therefore, reduce the amount of artificial light required.

I. Arrange work surfaces so that sidewall daylighting crosses the work surface perpendicular to the line of vision. (See FIGURE EIGHT)

FIGURE EIGHT



Recommended reflectances for surfaces and furnishings in the classroom. (Note: control media is used at windows to reduce exterior luminances so that they are in balance with interior luminances.)

J. Locate air-conditioning compressor in a shaded area or on the north side of the building

K. Use of solar film and sun screens on windows can reduce heat gain

UNIT ACTIVITIES

1. The student, after making his or her lighting survey in Unit I, should be able to make suggestions to improve the lighting efficiency for the area or areas surveyed.

2. The student should be able to measure the temperature of water (in a hot water heater) and also remove heating elements to determine if elements need to be replaced or cleaned.

3. The student should be able to determine proper installation methods for appliances, and review manufacturer's product guide for information regarding energy conservation.

4. The student should be able to check a heating and cooling system and make proper adjustments or install energy conservation devices.

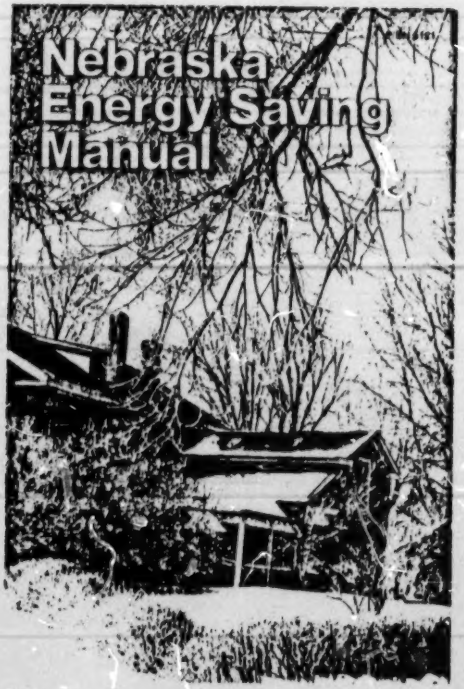
5. The student should survey the exterior of a building and make recommendations for landscaping that could save energy.

UNIT REFERENCES

The following publications are available from the:

Nebraska Energy Office
P.O. Box 95085
Lincoln, NE 68509

1. Nebraska Energy Saving Manual (50¢ per book)
2. Tips for Energy Savers



UNIT III

CONSERVATION METHODS FOR ELECTRICAL DESIGNERS

RATIONALE

Electrical equipment and systems design are two areas of potential energy savings. It is the responsibility of the electrical contractor to select equipment and plan electrical systems for energy efficiency. This unit is designed to provide the student with sufficient information to choose an electrical system resulting in the lowest use of electrical energy for any project.

ADVANCED PREPARATION

It is recommended that the publication, "Nebraska Energy Saving Manual", be obtained from the Nebraska Energy Office prior to beginning this unit. Manufacturer's catalogs, shop drawings, and electrical design manuals, (i.e. - 1981 National Electrical Code NFPA-70) are also essential for the successful completion of this unit.

ANTICIPATED INSTRUCTIONAL TIME

1-3 weeks

UNIT GUIDE

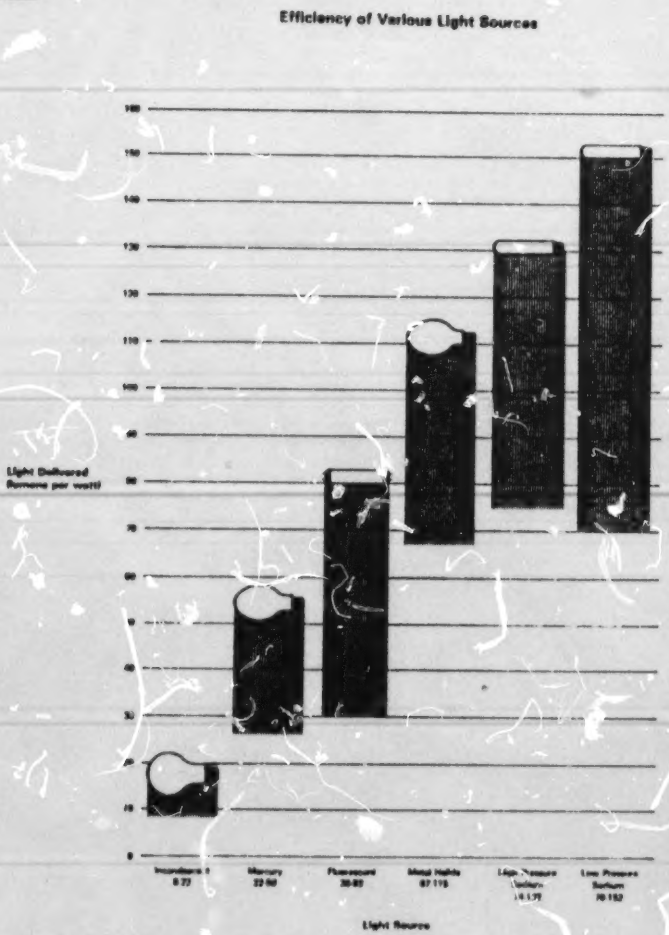
1. LIGHTING (see FIGURE NINE)

   A. High Pressure Sodium (HPS)
      1. High pressure sodium lighting will provide the highest lumens-per-watt (LPW) of any lighting type available today.
      2. Advantages
         a. Excellent for parking lots
         b. Can be mounted very high to provide good light dispersion
         c. 12,000 watts of HPS lighting mounted at 100 feet will replace 24,000 watts of HPS mounted at 40 feet.
      3. Disadvantages
         a. HPS lighting poses a problem where excellent color rendering is required.
         b. Extreme intensity and harsh shadows make HPS unsuitable for office, retail store, or classroom use.

      NOTE: Newer developments will produce an HPS lamp with much improved color rendition.

   B. Metal Halide
      1. Produces less lumens-per-watt than HPS
      2. Provides the best color rendering capabilities of all high intensity light sources and should be selected when that property is required.

FIGURE NINE


Efficiency of Various Light Sources
Light Delivered
Lumens per watt
Light Source

C. Mercury Vapor
The advantages and disadvantages of Mercury Vapor Lighting are very close to those of other high intensity discharge lighting with one important exception. The lumens-per-watt output is much less than all other common lighting types with the exception of incandescent so that Mercury Vapor should only be considered where low installation costs are of prime importance.

D. Fluorescent
1. This lighting type is not as efficient in lumens-per-watt delivered. However, wherever the absence of harsh shadows or bright reflections is desired, fluorescent lighting makes an excellent choice. It is widely used in:
   a. Offices
   b. Classrooms
   c. Retail stores

E. Incandescent
1. The relative low efficiency of incandescent lights indicates that this type of lighting should only be selected when:
   a. Space or other conditions prevent the use of more efficient lighting
   b. The number of hours of operation do not justify the additional cost of more efficient types.
2. Suggestions for improving the efficiency of existing incandescent lighting systems is given in Unit II.

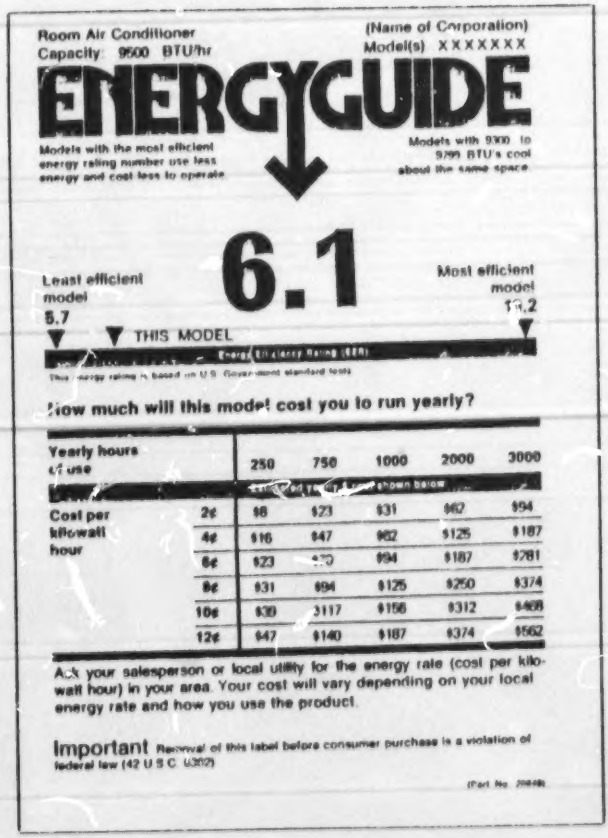
F. Selection
Whatever type of lighting fixture is selected, it is important to study the manufacturer's literature. Selection should always match the job. Criteria for selection include:
1. Lumens-per-watt delivered.
2. Energy efficiency
3. Area to be lighted
4. Building use

2 APPLIANCES

A Sizing
Before any appliance is purchased, a careful evaluation of its major use is warranted to ensure that the appliance is neither too large or too small for the required job.

B. Study the labels on the appliance (see FIGURE TEN)
1. The label on the appliance will provide the most accurate information. Printed literature supplied by the dealer may not exactly match the unit.
2. When selecting an appliance, be sure to consider the following information on the label:
   a. Energy Efficiency Ratio (the higher the number the better!)
   b. Coefficient of Performance
   c. Estimated yearly operating cost.
   d. Seasonal performance factor

FIGURE TEN


Room Air Conditioner
Capacity: 9500 BTU/hr
(Name of Corporation)
Model(s) XXXXXXX
ENERGYGUIDE
Models with the most efficient energy rating number use less energy and cost less to operate.
Models with 9300 to 9799 BTU's cool about the same space.
6.1
Least efficient model
8.7
Most efficient model
THIS MODEL
Energy Efficiency Rating (EER)
This energy rating is based on U.S. Government standard tests.
How much will this model cost you to run yearly?
Yearly hours of use
250
750
1000
2000
3000
Based on the hours shown below.
Cost per kilowatt hour
2¢ $8 $23 $31 $62 $94
4¢ $16 $47 $62 $125 $187
6¢ $23 $70 $94 $187 $281
8¢ $31 $94 $125 $250 $374
10¢ $39 $117 $156 $312 $468
12¢ $47 $140 $187 $374 $562
Ask your salesperson or local utility for the energy rate (cost per kilowatt hour) in your area. Your cost will vary depending on your local energy rate and how you use the product.
Important Removal of this label before consumer purchase is a violation of federal law (42 U.S.C. 6302)

3. MOTORS

A. Approximately 35 percent of all electrical energy generated in the United States is used to power electric motors.

B. Energy Efficiency Ratios (EER) are used to rate motors in their ability to operate economically. Low "EER" rated motors are the least expensive to purchase, which is the reason for the large availability of these motors.

C. A motor with a high "EER" will cost more than a motor with a lower "EER". The savings in operating costs, however, will quickly offset this added expense.

Example: A 10 horsepower replacement motor is needed. A choice of the following is given.

"EER" Rating	Cost	Use/Year	Expected Life
83%	$242.37	4,000 hours	35,000 hours
88%	$284.39	4,000 hours	35,000 hours

The less expensive motor, however, uses 500 watts more per hour. Even though the higher "EER" rated motor costs $42.02 more, it will pay for itself in just over 6 months of operation (if both motors are operated for 4,000 hours per year). Estimating a life expectancy of 35,000 hours for this motor, the higher "EER" rated motor will effect a savings of $671.98 in its lifetime.

D. Ensure that motors are provided with sufficient cooling air and ventilation. The efficiency of a motor is impaired when it is required to operate at a temperature higher than that for which it is designed.

E. Eliminate excessive stopping and restarting. This reduces the lifetime of the motor. Unnecessary restarts can be eliminated by:
1. Proper adjustment of HVAC controls
2. Proper design of mechanically driven equipment
3. Proper scheduling of tasks assigned to motors

F. Sizing
Selection of the correctly sized motor is imperative!
1. Undersized motors will overheat and burn out
2. Oversized motors will waste energy.

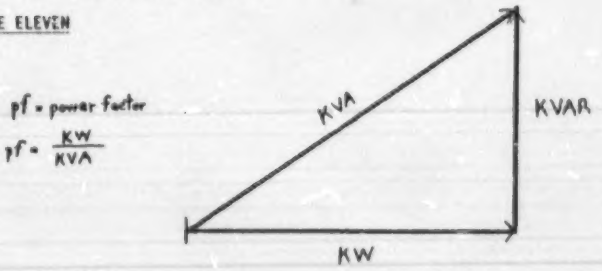
G. Correct sizing of motor branch circuits and controllers are necessary to ensure that excessive voltage drops are not created.

4. POWER FACTOR

A. Low power factor increases the power company's cost of supplying actual power, because more current must be generated. This higher cost is directly billed to large electrical energy users because of the power factor penalty clauses in rate schedules.

B. What is Power Factor?

FIGURE ELEVEN

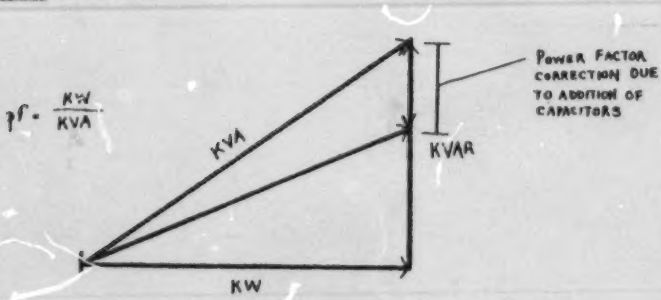


QUANTITY	POWER TYPE	SYMBOL	DESCRIPTION
P	Real Power	KW	The quantity of energy that is recorded on the utility electric meter
Q	Reaction Power	KVAR	The quantity of energy that is used to supply reactive loads of induction equipment. (Not recorded on the utility electric meter)
S	Apparent Power	KVA	The quantity of generated energy

The power factor, then, is simply an indication of the amount of power (S) that must be generated to supply a load made up of real (P) and reactive (Q) components. Power factor is expressed in percent with 100 percent indicating that real power (P) and apparent power (S) are equal.

C. Power Factor Correction
Power factor can be corrected or improved with the addition of capacitors across the load that is causing poor power factor. (See FIGURE TWELVE)

FIGURE TWELVE



D. Centralized Capacitors
Where there are many loads (at one facility) causing power factor decreases, a centralized capacitor location may be used. The main disadvantage of using centralized or "lumped" capacitor installations is that there is a possibility of overcorrection (as the load varies). Excessive capacitor loads will increase the line voltage and may cause damage to connected loads. New and sophisticated control devices have been developed which will switch capacitence on or off to prevent overcorrection. This will result in increased centralized capacitor use.

E. Advantages of Individual Capacitor Installations
1. Voltage drops to individual motors are reduced, decreasing damaging heat due to excessive currents.
2. Capacitors are switched in and out of service as they are needed. In this way, power factor is adjusted to "over-all" load requirements and better voltage regulation is obtained.
3. The capacitor values required for individual motors are easily chosen from tables, thus reducing engineering costs.
4. Individually corrected motors and other machines have a great flexibility in case of equipment rearrangments. No matter where the motor is located, proper correction is assured.
5. Reactive losses are present between the induction machine and the power factor correction device. Therefore, the greatest benefit is achieved when the capacitors are as close to the load as possible.

F. Advantages of Centralized Capacitor Installations

1. Centralized installation improves overall plant power factor, effecting a reduction in power bills.
2. Banks of capacitors have a lower cost per kilovar than individual capacitors.
3. The cost of bank installation wiring is lower per kilovar than the cost of wiring individual capacitors to their associated motors.

FIGURE THIRTEEN

SUGGESTED MAXIMUM CAPACITOR RATING WHEN MOTOR* AND CAPACITOR ARE SWITCHED AS UNIT

Induction Motor Horse Power Rating	Nominal Motor Speed in RPM					
	3600		1800		1200	
	Capacitor Rating KVAR	Line Current Reduction %	Capacitor Rating KVAR	Line Current Reduction %	Capacitor Rating KVAR	Line Current Reduction %
3	1.5	14	1.5	15	1.5	20
5	2	12	2	13	2	17
7.5	2.5	11	2.5	12	3	15
10	3	10	3	11	3.5	14
15	4	9	4	10	5	13
20	5	9	5	10	6.5	12
25	6	9	6	10	7.5	11
30	7	8	7	9	9	11
40	9	8	9	9	11	10
50	12	8	11	9	13	10
60	14	8	13	8	15	10
75	17	8	16	8	18	10
100	22	8	21	8	25	9
125	27	8	26	8	30	9
150	32.5	8	30	8	35	9
200	40	8	37.5	8	42.5	9
250	50	8	45	7	52.5	8
300	57.5	8	52.5	7	60	8
350	65	8	60	7	67.5	8
400	70	8	65	6	75	8
450	75	8	67.5	6	80	8
500	77.5	8	72.5	6	82.5	8

FIGURE THIRTEEN CONT.

SUGGESTED MAXIMUM CAPACITOR RATING WHEN MOTOR* AND CAPACITOR ARE SWITCHED AS UNIT

Induction Motor Horse Power Rating	Nominal Motor Speed in RPM					
	900		720		600	
	Capacitor Rating KVAR	Line Current Reduction %	Capacitor Rating KVAR	Line Current Reduction %	Capacitor Rating KVAR	Line Current Reduction %
3	2	27	2.5	35	3.5	41
5	3	25	4	32	4.5	37
7.5	4	22	5.5	30	6	34
10	5	21	6.5	27	7.5	31
15	6.5	18	8	23	9.5	27
20	7.5	16	9	21	12	25
25	9	15	11	20	14	23
30	10	14	12	18	16	22
40	12	13	15	16	20	20
50	15	12	19	15	24	19
60	18	11	22	15	27	19
75	21	10	26	14	32.5	18
100	27	10	32.5	13	40	17
125	32.5	10	40	13	47.5	16
150	37.5	10	47.5	12	52.5	15
200	47.5	10	60	12	65	14
250	57.5	9	70	11	77.5	13
300	65	9	80	11	87.5	12
350	75	9	87.5	10	95	11
400	85	9	95	10	105	11
450	92.5		100	9	110	11
500	97.5	9	107.5	9	115	10

5. MECHANICAL EQUIPMENT

Design with energy savings in mind!

A. Use low friction bearings

B. Direct drive couplings have less slippage and/or friction

C. Oversized rotating or moving parts result in unnecessary inertia

D. Carefully analyze what equipment will produce the most energy efficient design

E. An efficient lubrication system will reduce friction

6. ELECTRICAL SYSTEMS

A. The use of accepted engineering and design standards will result in an electrical installation that will perform as desired.

B. Careful voltage drop calculations will ensure that no excessive low voltage conditions are created. This is particularly important where long feeder or branch circuit conductors are necessary such as those installed on center pivot irrigation systems or where high ambient temperatures are present.

C. The general lighting demand loads required in table 220-2(b) of the National Electrical Code indicates the amount of electrical service required in the building. It is not necessary to install this amount of light in the building, if light level studies indicate that lower levels of light will produce the desired effect.

UNIT ACTIVITIES

1. Have students examine an existing lighting installation and redesign it for energy efficiency to include an analysis of:
   A. Total energy savings
   B. Cost savings
   C. Payback period

2. Students should be able to review a manufacturer's lamp catalog and construct a chart showing the relative difference in lumens-per-watt for different lighting sources.

3. Students should be able to review a fixture manufacturer's catalog and determine the better luminaire for providing the desired foot-candle level.

4. Students should be able to compute voltage drop problems and calculate the energy saved by having a properly designed system.

UNIT REFERENCES

1. 1981 National Electrical Code NFPA-70
2. A Guide to Power Factor Correction, Sprague Electric Company, North Adams, Massachusetts

UNIT IV

CONSERVATION METHODS FOR ELECTRICAL CONTRACTORS

RATIONALE

Electrical contractors can save a substantial amount of energy by simply being aware of all areas where potential energy waste occurs and performing quality workmanship to prevent energy loss. When needless waste is eliminated, contractors can concentrate on refining techniques to optimize the efficient use of energy. This Unit, therefore, is designed to provide the student with information concerning methods for electrical contractors to conserve energy.

ADVANCED PREPARATION

It is recommended that the publications, "Nebraska Energy Saving Manual" and "Tips for Energy Savers" be obtained from the Nebraska Energy Office prior to beginning this Unit.

ANTICIPATED INSTRUCTION TIME

1-3 weeks

UNIT GUIDE

1. LIGHTING

   Conservation of energy by the reduction of lighting levels may affect other building requirements. This conservation measure must therefore be performed consistent with:

   A. Productivity

   B. Visual acuity

   C. Aesthetics

   D. Federal codes*

   E. State codes*

   F. Local codes*

   G. Heating and cooling systems

*NOTE: Always reference the most STRINGENT building code/lighting standard affecting the locality. Where no local codes exist, minimum thermal/lighting standards have been established by the Nebraska Energy Office (ASHRAE 90-75) and MUST be complied with.

2. ESTABLISH AN EFFECTIVE LIGHT USAGE PROGRAM

A. Personnel should be assigned, trained, and made responsible for the efficient utilization of lighting by means of established schedules for the control of lighting.

B. Define the exact nature of occupancy for each time period.

C. Determine the minimum amount of lighting needed for safety and security purposes.

D. Color code switches consistent with system lighting schedules

3. MAINTENANCE CONSIDERATIONS

A. Check lighting levels with a calibrated light meter

B. When the light output of a group of luminaires has fallen below 70% of original level, replace all luminaires simultaneously.

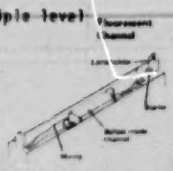
C. Lamp and luminaires should be wiped clean at regular intervals.

D. Replace lenses that have "yellowed" with clear acrylic lenses.

E. If lamps in fluorescent fixtures have been removed, remove the ballast as well. Unremoved ballasts continue to consume energy.

F. Consider installing fluorescent luminaires with multiple level ballasts.

G. Consider lowering luminaire levels
   1. Set levels to provide required illumination
   2. Wattage will be reduced



4. CONTROLS

A. Consider the use of photocells to switch off banks of lighting when :
   1. Natural light will provide the required lighting
   2. On vacation
   3. On weekends

B. Use neon indicators to monitor lights in remote areas.

C. Use time controls for those areas of a building in which lights are used infrequently or only for brief periods.

D. Use motion sensing devices to control lighting. These will automatically turn lights:
   1. "On" when a person enters
   2. "Off" when a person leaves.

5. INSTALLATION OF LUMINAIRES

A. Check for infiltration around ceiling boxes, recessed fixtures, and troffers.

B. Check branch circuit load calculations for wire sizing and voltage drop.

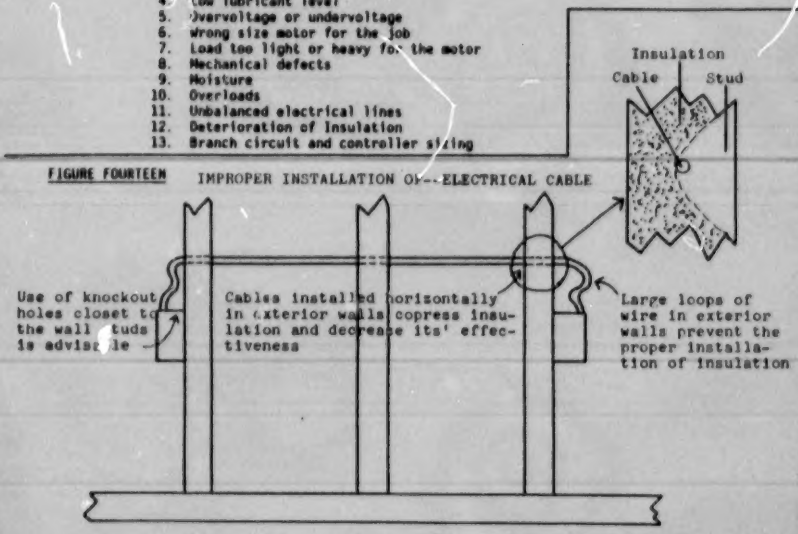
C. Check light sockets and fluorescent lampholders for tight connections that may cause heat buildup.

6. MOTORS

A. Schedule a regular routine maintenance program and keep records of dates and type of maintenance performed.

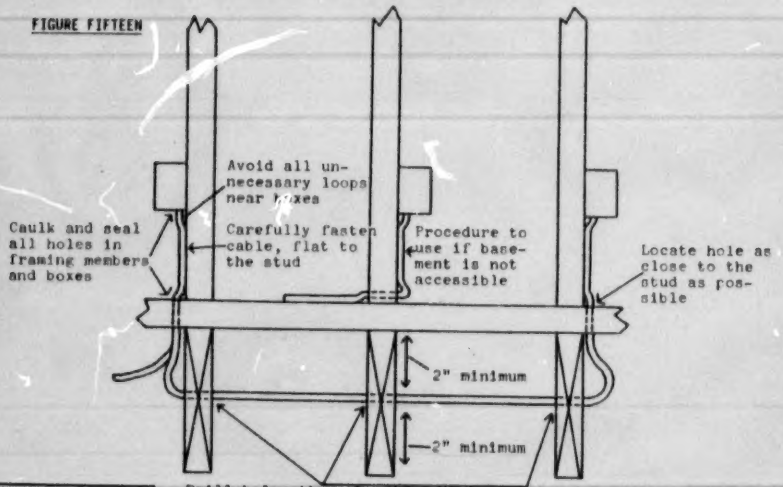
B. Routine checks should be performed for the following
   1. Improper alignment
   2. Loose connections
   3. Dirt accumulation
   4. Low lubricant level
   5. Overvoltage or undervoltage
   6. Wrong size motor for the job
   7. Load too light or heavy for the motor
   8. Mechanical defects
   9. Moisture
   10. Overloads
   11. Unbalanced electrical lines
   12. Deterioration of Insulation
   13. Branch circuit and controller sizing

FIGURE FOURTEEN IMPROPER INSTALLATION OF ELECTRICAL CABLE


Insulation
Cable
Stud
Use of knockout holes closet to the wall studs is advisable
Cables installed horizontally in exterior walls copress insulation and decrease its' effectiveness
Large loops of wire in exterior walls prevent the proper installation of insulation

PROPER INSTALLATION OF ELECTRICAL CABLE

FIGURE FIFTEEN


Avoid all unnecessary loops near boxes
Caulk and seal all holes in framing members and boxes
Carefully fasten cable, flat to the stud
Procedure to use if basement is not accessible
Locate hole as close to the stud as possible
2" minimum
2" minimum
Drill holes through cables in basement far enough from the sill to avoid interference with insulation

UNIT ACTIVITIES

1. The student should be able to identify the practices which an electrician can use to prevent losses through infiltration.
2. The student should be able to present methods that electricians may use to counsel consumers in conserving electrical energy.
3. The student should be able to use a lighting catalog and engineering charts to determine proper fixture mounting methods.
4. The student should be able to demonstrate the mounting of electrical fixtures for the lowest friction losses.

UNIT REFERENCES

The following publications are available from the:

Nebraska Energy Office
P.O. Box 95085
Lincoln, NE 68509

1. Nebraska Energy Saving Manual (50¢ per book)
2. Tips for Energy Savers

UNIT IV

A LOOK BEYOND

RATIONALE

Any individuals directly involved in the conservation and efficient use of energy must be prepared to answer questions outside their specific area(s) of expertise. It is the responsibility of the electrical tradesman to keep abreast of the latest developments in electrical technology and become literate in all related areas. This unit is designed, therefore, to provide information related to the electrical discipline.

ADVANCED PREPARATION

It is recommended that the publications "How to Start an Energy Management Program" and "The Total Energy Management Handbook" be obtained from the Nebraska Energy Office prior to beginning this unit.

ANTICIPATED INSTRUCTIONAL TIME

1-3 days

UNIT GUIDE

1. PRODUCT INFORMATION

   For information regarding new product development, the following contacts are suggested:

   A. Nebraska Energy Office

   B. United States Department of Energy

   C. Energy Information Administration

   D. Energy User News

   E. Energy Management Report

   F. Electrical Trade Publications

   G. Various Energy Conservation Publications

2. CURRICULUM GUIDES

   A curriculum guide (such as this) or other instructional materials will rapidly become outdated as new developments in the field of electrical energy conservation are becoming realities. It is the responsibility of the instructor to keep abreast of all new developments.

3. ALTERNATIVE ELECTRICAL POWER SOURCES

Use of electrical energy from sources other than electric utility companies are fast becoming attractive alternatives. The widespread use of any alternative to fossil fuels will not occur until its cost/effective ratio is competitive with fossil fuels. Alternative sources will, however, conserve rapidly diminishing fossil fuel supplies and should be promoted wherever they are feasible. Some of the more attractive alternatives include:

A. Solar Energy from Photovoltaic Conversion

1. Economics

Despite the promise of electricity generated by solar cells, economics remain a serious barrier to its more widespread use. In 1976 solar cell modules suitable for use on land were priced at $15 to $20 per peak watt. This is substantially lower than the $80 price in the space program, where higher quality control standards are necessary, because land-based equipment can be maintained periodically and repaired when necessary.

But even at $15 to $20, a 20 x 30-foot panel of solar cells would cost $75,000 to $100,000. While initial costs are high, operating costs for solar electric systems would be relatively low. There would be no fuel bills, and the cells have a high potential for reliability and long life. Maintenance requirements are extremely low. Rain, for example, takes care of cleaning the solar cell surfaces.

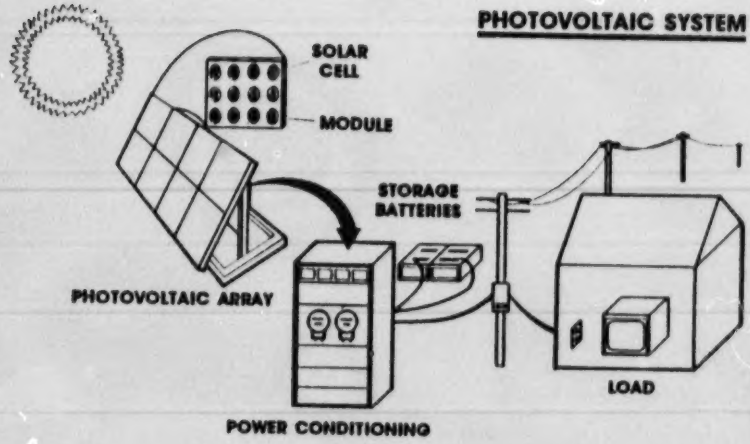
Solar cells are expensive because their fabrication is largely a handcrafting process. A single crystal of extremely pure silicon is artificially grown in the form of an ingot; wafers cut from the ingot are polished and trimmed; the impurities are diffused into the silicon in an oven; electrical connections are added; and the finished cells are mounted in arrays. Some improvements have already been made in manufacturing methods and quality control, and the outlook seems good for future progress.

In one recent promising development, silicon solar cells were produced continuously in the form of ribbons as thin as a human hair. This process might lead to mass production, which would dramatically lower costs. Another approach under investigation at DOE is to use other semiconductors that offer the possibility of lower production costs or higher conversion efficiency. One such material, cadmium sulfide, appears capable of being produced at less than $1 per peak watt.

2. Future Prospects

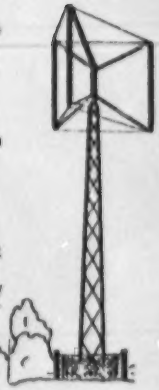
The goal of DOE's program in photovoltaic conversion is to solve the technical and economic problems standing in the way of widespread use of solar cells. For remote applications of 10 to 100 watts, they are already economically competitive. The costs of systems presently being marketed ranges from $30 to $70 per peak watt, including the array, storage batteries, regulators, and power conditioners. Larger scale applications will require much lower prices. DOE's efforts are aimed at bringing the price of solar cells down to $0.50 per pak watt by the mid-1980s . At this price, electricity from solar cells might well make a substantial contribution to meeting the Nation's energy needs, especially since the cost of present methods of generating energy will probably also be rising.

FIGURE SIXTEEN



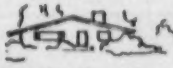
B. WIND GENERATION

1. Solving Developmental Problems



The primary obstacle to using wind energy now is that it is more expensive than conventional energy sources in most applications. DOE is striving to reduce costs to 2-4 cents per kilowatt hour so that wind energy will be competitive with fossil, hydroelectric, and nuclear energy sources.

A second problem with wind - as every sailor knows - is that it is not always available when needed. With the present high cost of energy storage facilities, the variability of wind energy is a characteristic that must be accepted. But it is not a serious problem. Wind turbines can save large amounts of fuel when the wind is blowing, and as long as the percentage of wind energy used in a system is not too large, separate storage systems are not really required. For example, a utility electrical system serves as an excellent storage place and some applications do not require constant power on demand. When a large multi-unit network of wind turbines spans two or more wind areas, utilities may achieve a statistical increase in their generating capacity without storage.



2. Limits of Wind Energy

Despite its environmental attractiveness as a nonpolluting power source, wind probably could not provide a large fraction of the total U.S. energy requirement because of its variability. However, it could provide much-needed additional generating capacity for utilities and save large amounts of fuel by becoming a significant source of energy for smaller utilities, rural homes, and agricultural areas.

3. Prospects for Wind Energy Development

Hundreds of small wind turbines are already in use throughout the country. Working in partnership with industry through its Rocky Flats and USDA programs, DOE hopes to reduce the cost and increase the reliability of these systems. Advanced 1-,8-, and 40-kilowatt wind turbines are being developed.

Harnessing wind power on a megawatt scale will require large capital investments. DOE is trying to improve the performance per unit cost of these systems, and also to test a number of large experimental machines under actual operating conditions. It may be possible to have a large multi-unit pilot plant operating by the early 1980s.

C. Other electrical alternatives
   1. Privately owned streams are sometimes used for hydro-electric generation.
   2. Laser transmission of electrical energy
   3. Individual nuclear power supplies are being considered.

UNIT ACTIVITIES

1. Have students research various journals, catalogs, publications, etc. and report their findings regarding:
   A. Product information
   B. Photovoltaic cells
   C. Wind generators
   D. Other alternatives

2. Students should be able to determine the cost/effectiveness of utilizing various alternative electric generation sources.

UNIT REFERENCES

The following publications are available from the:

Nebraska Energy Office
P.O. Box 95085
Lincoln, NE 68509

1. How to Start an Energy Management Program
2. The Total Energy Management Handbook
3. The Solar Cell
4. Solar Electricity from Photovoltaic Conversion
5. Wind Energy